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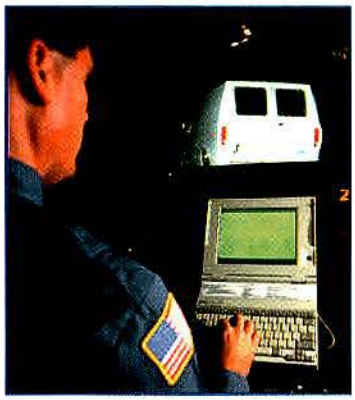
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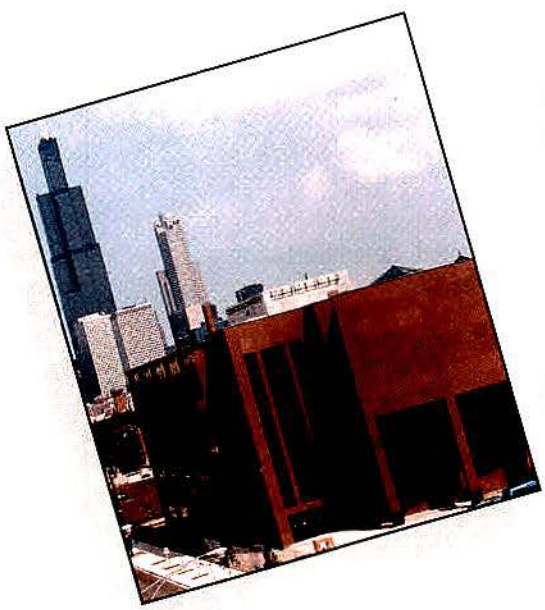


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Monitoring the changes in public safety communications

News-gathering organizations object to digital technologies that limit their ability to monitor wireless public safety communications. Some compromises allow limited monitoring while addressing safety issues.

By Rikki T. Lee

"All units in the vicinity of 1740 South Boston. Neighbor reports gunshots. Proceed Code Three. Over ... "

"This is One-Five-Seven; am two blocks from 1740 South Boston. Request background check on resident. Over ... "

"One-Five-Seven, your background on resident at 1740 South Boston. Name Sam Smith, male, Caucasian, 37 years of age, height 6-2, weight 250. Two priors: October 1993, D&D; April 1994, assault. Over ... "

"This is One-Five-Seven, 10-4. We are approaching suspect's front entrance. Over ... "

Monitoring the status of a routine police call seems like an innocent pastime for off-duty security guards, hobbyists, technicians, radio shop owners and many others with access to a conventional scanner. Scanning the frequencies for motor-vehicle accident reports can prove profitable for independent tow-truck operators. Local broadcast news teams that monitor the police channels and that arrive at an accident or crime scene as quickly as possible may get a jump on rival stations for an important late-breaking story (with film at 11). For many years private citizens—and the news media—have assumed it to be an inalienable right to use the scanner to monitor the airwaves.

Lee, previously the editor of *Radio Resource* magazine, is a Denver-based writer and editorial consultant specializing in the wireless communications industry. Tel. 303-745-7481.



This screen displays a cumulative record of dispatch calls at the Kansas City, MO, police department (KCPD) using a computer connected with a radio tuned to the data channel. It also displays status messages from officers.

Limited eavesdropping

That is going to change as more and more public safety agencies around the United States adopt technologies such as trunking, digital voice, encryption and mobile data. A public agency's license to transmit does not restrict its right, if necessary, to send out secure information in a digital or encrypted format. Advantages for the agency include: improved spectrum efficiency, quicker access to a channel, enhanced voice and data security and, perhaps most important, increased officer safety.

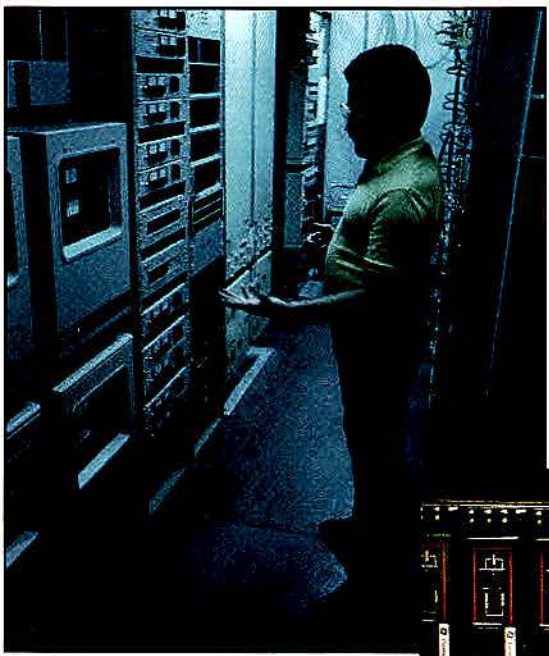
Trunking and digital technologies have affected—and will continue to affect—the relationship between public safety and scanner users (especially the local news media). Unfortunately, in cities where police departments in past months have switched from conventional VHF and UHF communications to 800MHz trunking (for example, Denver and Kansas City, MO, which have implemented Ericsson's EDACS system), the news media have on occasion been less than objective in their approach to reporting this changeover in technology. Some public safety agencies have found ways to implement new technology and still keep their communities informed.

When both law enforcement and the community continue to work together—no matter what two-way technology is used—everybody wins.

Trunked transmissions

The various trunking systems available for public safety differ somewhat in the details, but they follow a general formula. Controlled by logic circuitry, a trunking system keeps all frequencies open to all radios—thus increasing the likelihood that at least one channel will be unblocked and free to use. When a talkgroup is selected on the radio and the push-to-talk switch is activated, the system automatically assigns a caller to the next available channel. In some systems, the same channel may "hang" for a response; in others, that frequency immediately becomes available for the next user.

Voice transmissions over a trunked network can be in either analog or digital mode. With analog trunking, scanning is possible, yet difficult. (Within the monitoring community, the frequencies on a new public safety trunked system don't remain secrets for very long.) Someone using a conventional scanner with 800MHz or 900MHz frequencies often can pick up enough information from an analog conversation to understand what is going on. For example, hearing even a few words could be sufficient for a scanner user to discern whose residence is being targeted. Using several scanners set to different frequencies increases the likelihood that a more comprehensible



Dean Hart, supervisor for radio maintenance at KCPD inspects power supplies for the new radio communications equipment to be activated in the summer of 1995.

transmission can be pieced together.

Digital modulation

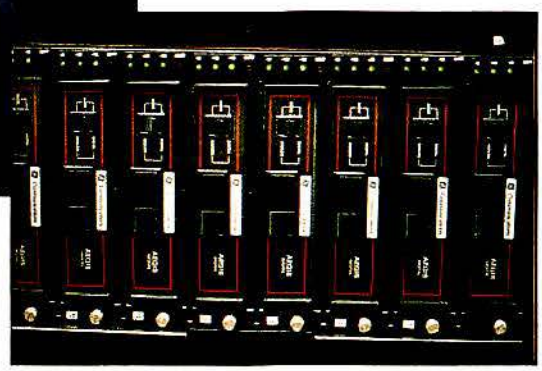
The next level in trunking is the addition of digital modulation for some or all of a department's talkgroups. For example Ericsson's digital form of the company's EDACS trunked system, Aegis, is a high-speed digital communications technology. The analog voice input is digitized using a sophisticated digital speed coding technology, or vocoder. Added to the vocoded message are features such as channel signaling (which synchronizes the signal at the receiving end) as well as error detection and correction.

The technique for converting analog speech signals to a digital data stream is called *vocoding*, short for "voice encoding." The process consists of first sampling the input speech signal at the standard rate of 5,800 samples per second. Each sample is assigned a "code" of eight bits, producing a data stream of 46.4kbps. The heart of the vocoding process now consists of "compressing" this high data rate to a lower, more manageable data rate to fit within a radio channel. The Aegis technology compresses the data using an advanced digital signal processing algorithm called *adaptive multiband encoding* (AME). AME transforms the analog voice input to a digital signal with a gross signaling rate of 9,600bps.

When an Aegis radio receives the digital transmission, it automatically decodes the data message into an analog voice signal. At no time as the signal travels over the air does it ever become intelligible to the human ear or to a monitor receiver. Instead, the signal sounds like an anonymous burst of data—a rude wake-up call for many scanner enthusiasts.

Restricted monitoring

A trunked system using digital voice makes monitoring by outsiders much more difficult without the proper—and highly expensive—equipment.



This is the Aegis equipment that brought encryption issues to the attention of Kansas City, MO, news-gathering organizations and private security companies.

"You can't really go to Radio Shack to buy digital vocoders, but they are available, and you can purchase them," said John Suzuki, manager of systems and networks product marketing for Ericsson's Private Radio Systems division. "Just the fact that a department has gone digital increases its security over the use of analog, but it still doesn't offer full security." If a digital police radio were ever to be stolen or picked up by unauthorized personnel, the dispatch supervisor could render it useless with a remotely addressed signal.

Encryption

The next step up the voice security ladder is digital encryption. Often, tactical teams are the first in a police department to use encryption. With this technology, the signal consisting of zeros and ones is randomly jumbled according to an algorithm such as the National Security Agency's Digital Encryption Standard (DES) or Ericsson's own Voice Guard encryption. Only those radios equipped with a DES chip can decode the signals and transmit encrypted messages of their own. With billions of unique codekey possibilities that can be changed at will by the user, the chances of anyone with even state-of-military-art decrypting technology being able to "crack the code" is highy unlikely.

The final stage in a secure communications environment is to go completely voiceless, moving to mobile data. Instead of a voice message being sent by the dispatcher, text information in the form of a data burst is transmitted over the radio system and into the appropriate vehicle's mobile data terminal or laptop computer. When integrated into a voice-and-data trunked system, mobile data provides completely uncompromisable, multilevel digital security. No civilians can monitor mobile data transmissions. Despite the high efficiency and security of mobile data, many police departments with this technology often use voice—either analog or digital—as the main form of dispatch.

Police stories

One venue of news media furor over digital trunking is Kansas City, MO, which is switching over to encrypted Aegis radios this summer. Dean Hart, supervisor of radio maintenance for the Kansas City Police Department, said, "We can dispatch all the information we normally can't transmit over a clear voice channel. Armed with this information, the officer gets more insight before entering a situation—for example, with a suspect who ... has a past criminal record. It's a huge officer safety factor, and when approaching a disturbance, officers need to be at the scene without the media getting there first."

About three years ago, the Denver Police Department switched to 800MHz EDACS trunking. This new technology has helped to increase the safety of Denver police officers. Larry Fenstemaker, superintendent of the department's Electronic Engineering Bureau, said, "Take the situation of a raid at the location of a known drug dealer. If those suspects have the capability of monitoring our communications, it increases the possibility of officers getting killed as they go through the door. So it's a real asset for a department to have secure communications."

Conventional scanners can still pick up fragments of trunked analog transmission, but the results are not as satisfactory to the media and serious hobbyists. In Denver, however, the police department has given private citizens and the news media an opportunity to monitor certain talkgroups. After purchasing an EDACS receiver from an authorized Ericsson dealer, the user can, for an

additional $30, have it programmed by the department with police, fire, EMS and Denver International Airport talkgroups. Said Fenstemaker, "We've openly given permission for citizens, tow-truck drivers and the news media to monitor 90% of our communications. What we don't want is anyone having access to covert talkgroups. When you allow these radios to be placed in the hands of anyone with sophisticated hardware and software, you begin compromising the department's overall communications structure."



KCPD communications supervisors such as Steve Hoskins (left) can observe dispatchers at positions on two tiers of risers above the floor level of the supervisory positions.

In other cases, when a department that migrates to completely digital trunking allows authorized scanner users to monitor police frequencies, a dispatcher may send out the initial transmisison in clear voice mode. From the moment that this signal reaches the officer's radio, it gets digitized (and perhaps encrypted). Any subsequent voice traffic between dispatcher and officer will become digital and unintelligible to scanners, thus allowing more detailed and sensitive information to be transferred.

Computer monitor

Kansas City's Hart said, "When we talked to the media about going digital, we offered them a computer-aided dispatch (CAD) solution that would show them every call going out. When 9-1-1 received the call, the caller's phone number and address would appear using the automatic number identification/automatic location identification (ANI/ALI) system. The 9-1-1 telecommunicator would also type additional remarks to the radio dispatcher. Some of the remarks would be filtered out, but the initial call would go straight to the news media after the dispatcher logged in the call." The information going out to the media would include the location of the scene and the type of call (e.g., traffic accident, shooting or robbery).

Such a CAD solution would require each media user to purchase a computer monitor, plus pay installation and maintenance fees to the department. To stay on top of things, a media staffer would have to keep a constant eye on the CAD monitor for any newsworthy incidents. The days of reporters listening in on police activity with a mobile scanner and rushing to the crime or accident site already may be numbered. Public agencies are not required to provide anyone with the key to unlock their trunked,

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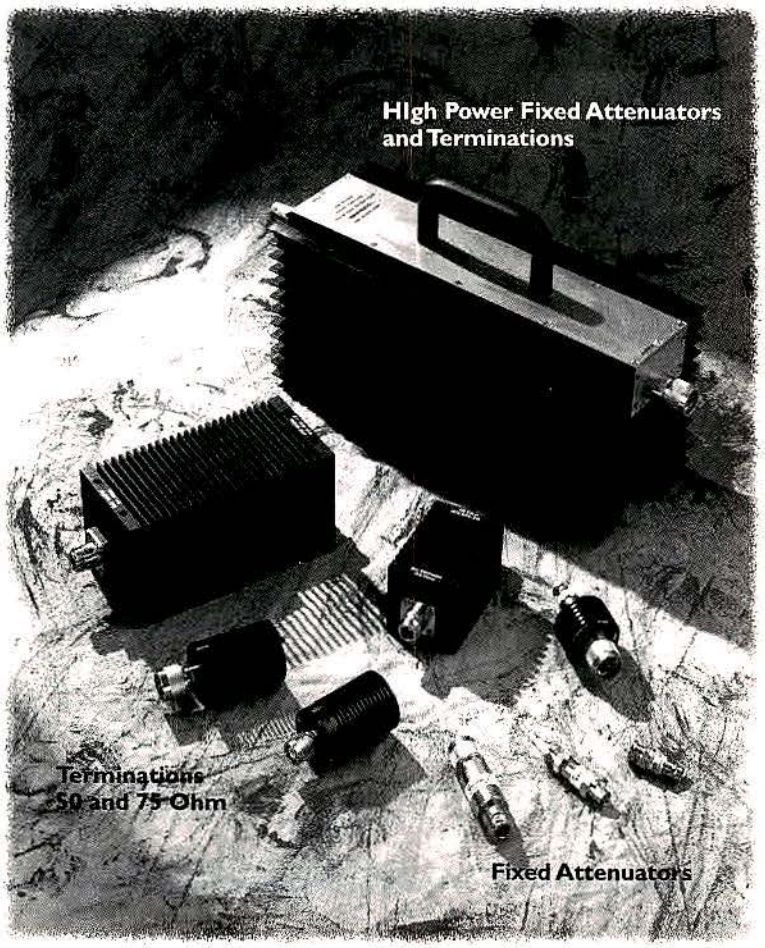
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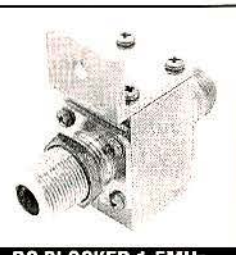
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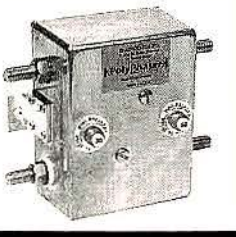
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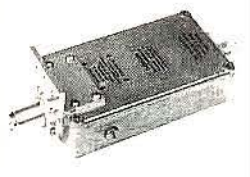
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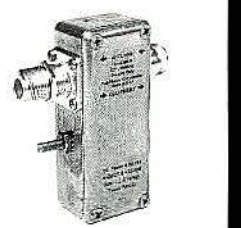
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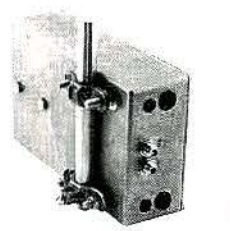
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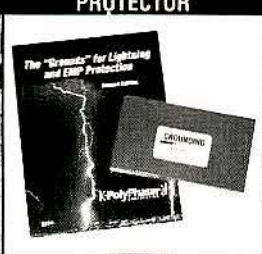
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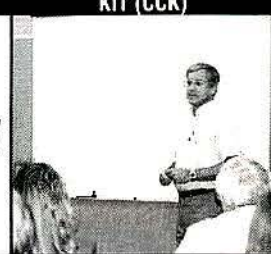
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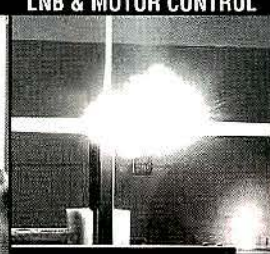
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digital or encrypted communications traffic.

Mobile data

However, the CAD setup also would be effective—and necessary—for the media if the police department transfers to a voiceless mobile data environment. Both the Kansas City and the Denver police departments plan to implement mobile data pilot projects this summer. Said Hart, "Once we go to voiceless dispatching, that CAD system is really the only dispatch solution the media is going to get. We wanted to do that now so we could get things worked out in advance and have it perfected by the time we go voiceless."

Other law enforcement agencies have found different approaches in keeping the media informed. The Manatee County, FL, Sheriff's Department has been using a few Ericsson Voice Guard radios, Aegis radios and mobile data for some of its officers for several years. Members of the media often carried 800MHz scanners that enabled them to pick up bits and pieces of analog police dispatches. All that changed when Manatee County went digital.

According to 1st Lt. Steve Litschauer of the Manatee County Sheriff's Office Support Division (and chairman of the Florida EDACS Users Group and co-chairman of the national group), "We have to look out for the safety and security of our officers. To do that, we need to have some degree of confidentiality of information we send out. However, we work well with the media. If any major incident within law enforcement occurs, our public information officer contacts the media immediately and faxes press releases instantly. Manatee County fire districts have members of the media on their paging system in case of emergencies. In addition, radio and TV stations have learned to call us to reassure [themselves] that nothing has gone unnoticed."

Officer safety

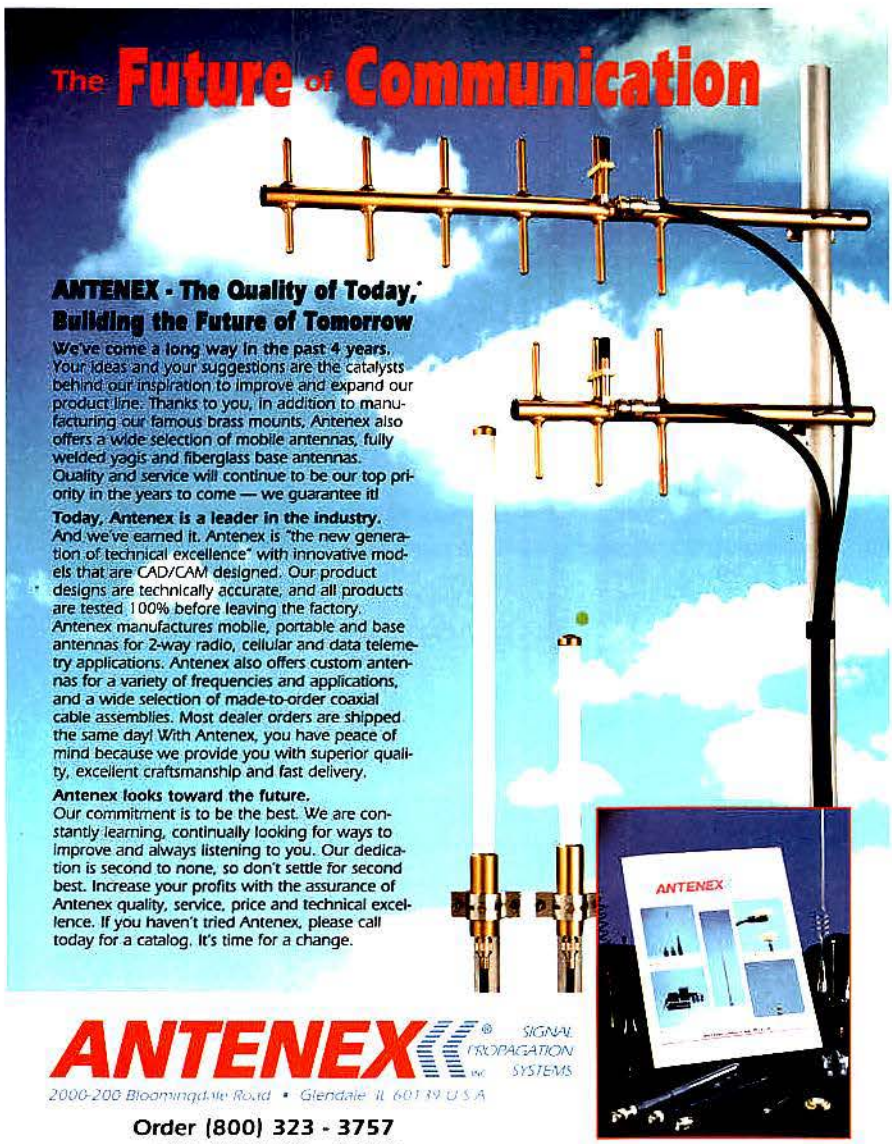
In the future, more law enforcement agencies may just decide to keep unauthorized listeners—including the media—out of the radio loop.

"If the media are truly concerned about officer safety," said Hart, "they must know that our officers come first. If the officers can do their job without the media following them, they can capture the criminals (who may also have scanners). Dispatchers can pass out critical information that helps officers to protect themselves."

Finally, along with the benefits of trunking and digital technologies for the department comes the need to train technicians to a higher level of performance. "Our trunked system is efficient and is steadily upgradeable by mostly changing or adding software," Fenstemaker said. "It's still state-of-the-art technology seven years later. Trunking is the wave of the future. But when you have trunking, it's complex. Every radio has a computer in it. Technicians have to be above average to develop skills to be proficient in the service of 800MHz trunked radios. Service-oriented agencies must have adept technicians to acquire the necessary skills. It's highly advisable to set up a preventive maintenance program and stick with it."

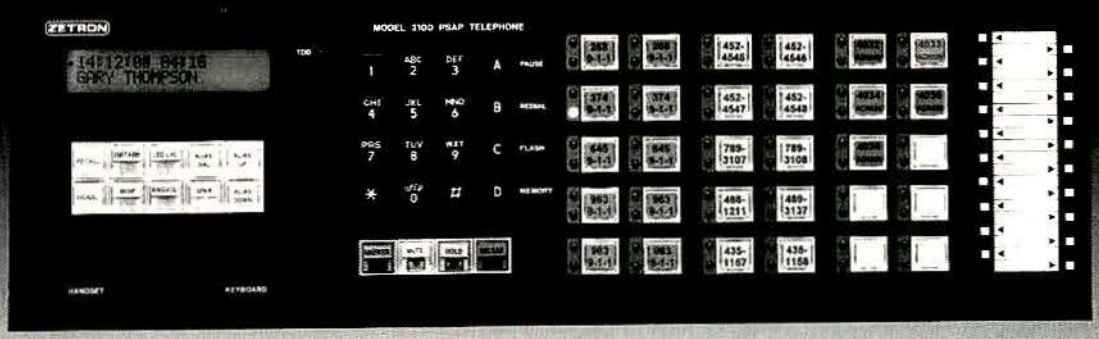
Acknowledgments

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Communications system keeps air ambulance service flying

Optimum base station sites linked into a VHF highband simplex network deliver voice and positioning communications almost everywhere that ambulance service aircraft fly near Greater Pittsburgh.

By Dennis Presky and Jack Robert

Landing a helicopter at the scene of a serious traffic accident, picking up a victim and taking off again is risky even under good conditions, and usually conditions are anything but good. To be without good communications when nothing else is going right increases the already large risk. Improved communications can prevent a craft from landing in the wrong place or reduce the time spent flying around in search of a ground vehicle—complications that really happen.

Upgrading STAT MedEvac's air ambulance communications center at the University of Pittsburgh Medical Center helped the service to provide critical-care transport for six large institutions, which in turn operate 14 in-patient care facilities with 4,500 beds in Greater Pittsburgh. STAT MedEvac uses six helicopters for regional transport and two fixed-wing aircraft (one turbo-prop and one Learjet) for long-distance flights.

Presky has owned and operated MRA, a communications company in Washington, PA, for 20 years. Previously he was a communications engineer for RCA. His primary work as a communications system consultant is in systems integration for medical research and emergency medical services. Robert is editor of *Advantage*, a newsletter published by Zetron, Redmond, WA. His articles about aviation, aerospace, software, telecommunications and electronics have appeared in technical publications.



A STAT MedEvac helicopter meets ground vehicles to speed the transportation of patients to medical facilities.

From Lake Erie to West Virginia

STAT MedEvac operates six helicopter bases located strategically throughout the area to cover 30,000 square miles. In addition to western Pennsylvania, helicopters cover parts of Ohio, Maryland, Virginia and West Virginia. Helicopters are dispatched an average of 10 times a day.

Devising adequate radio coverage was challenging. "Until about two years ago, we did our dispatching from a single-position Motorola 1600 Series console with a single transmitter on the medical center's roof," said STAT MedEvac's director of operations, James Bothwell. "It gave us very minimal coverage. Usually we had to call the base sites on the telephone to tell them they had a flight. Once the aircraft reached altitude, we could communicate with them, but when they descended, they were out of contact again.

"If the helicopter can't communicate with everybody when it's near the landing zone, you've got big problems. You have a patient on the ground who's in critical condition, you've got a ground crew that's getting very anxious for air support, and you've got a helicopter that's flying blind. That's entirely unacceptable." To address this issue, two years ago STAT MedEvac was awarded funding to upgrade its communications system. After a competitive bid process, the contract was awarded to MRA.

Consulting the 'experts'

Rather than STAT MedEvac's administration dictating the communications system configuration, employees were surveyed for information and ideas. Communication specialists, flight medics, pilots, doctors and nurses—everyone but the patients—gave information used to determine which existing system components and processes were useful and what the employees would like to see added.

The radio system design objective included 100% coverage of the region. It was reasoned that if communications could be maintained with a helicopter sitting on the

ground anywhere within the coverage perimeter, communications could be maintained under any other circumstances. The service's helicopters use 10W radios (maximum power for aircraft) and belly-mounted antennas. In addition, the service uses a non-repeated VHF highband simplex channel. Changing to a UHF repeater is impractical because everybody who already uses radio to communicate with the air ambulance service would have to change.

Placing elements of the transmission network raised interesting challenges because of the terrain. Its highest elevation is 3,200 feet above sea level, the average elevation is about 1,000 feet, and transitional elevation changes of 500 feet on quarter-mile intervals are not uncommon. Creative linking was required to complete a transmitter network.

Hot links

How best to link the transmitters was a key issue. Microwave links would have provided the best technical performance, but they are too expensive. Linking via splinter frequencies was selected as the best compromise.

Using the splinter pairs between the med channels, all the remote sites are linked with 2W UHF transmitters. A series of E.F. Johnson Challenger mobile units configured as base stations are cross-connected to Johnson 2W repeaters. The dispatch center also has a local base station with battery backup for redundancy in case of a power failure at the hospital. The local base station can sustain communications when utility power fails and before the hospital's generators come on line, or when a network link might fail.

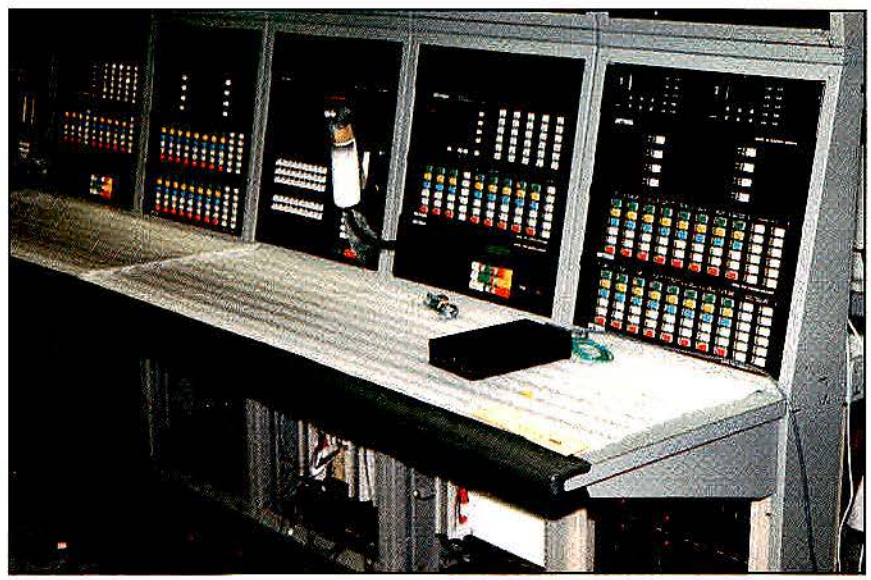
Various sites in the area were examined, and several were selected that would offer the best coverage for the money. Among them is a 2,800-foot mountain ridge in the Uniontown area. Another transmitter was installed at a ski lodge that participates in the medical helicopter group. The lodge has a 2,980-foot knob with a water tank on it. A 110-foot tower was erected atop the tank to achieve a 3,100-foot site elevation. STAT MedEvac also was given permission to use an abandoned U.S. Forest Service lookout tower that provides a 2,900-foot-elevation site.

Farther north, rented tower space and a remote base on the 18-story University of Pittsburgh Bio-medical Sciences Tower are the last two sites. These site configurations provide about 90% coverage on the ground in western Pennsylvania, Bothwell said.

Voting

With all sites on the same 155.265MHz highband frequency and the same continuous tone-controlled squelch system (CTCSS) squelch tone, if two or more sites pick up a call, the Hall Electronics signal-to-noise voting system decides which site has the best reception, and the base operator hears audio from that site. The Hall system was selected based on its reliability and price.

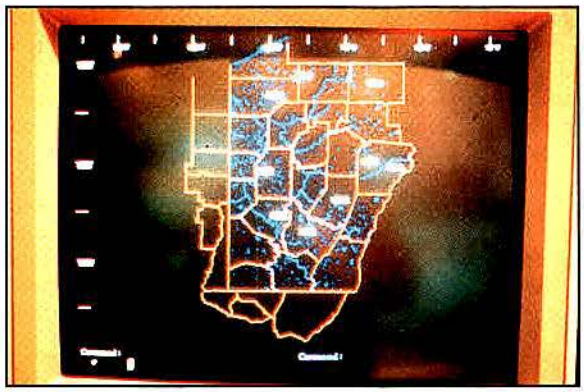
STAT MedEvac's computer-aided dispatch (CAD) system was developed by Innovative Engineering of Lebanon, NH, which designs dispatch systems specifically for air medical transport operations. It offers unique capabilities, such as the ability to read coordinates provided by the navigation equipment. The communication specialists dispatch with Zetron consoles driven by a 24-channel Zetron common control. The console equipment consists of two rack-mounted operator positions, plus a tabletop position, which is used primarily for backup. The tabletop position could be activated for supplemental



STAT MedEvac's console, photographed while under construction, includes two identical positions, each with three rows of slots. Within the three right-hand racks (beginning at the left of the microphone) are a Zetron model 21 instant recall recorder and two spaces containing telephone equipment. The center-right row contains a model 25 encoder, a model 4115 expansion panel and a model 4118 rack-mount console. The far right rack contains a model 27 monitor panel (top) and two model 4115 panels.



Communication specialists work at the completed console. In addition to these two positions, a desktop position (not shown) is used for training and emergency backup.



This cathode-ray tube (CRT) displays Global Positioning System (GPS) navigation data to show the current location of aircraft in a multistate area.

communications during a disaster. All three positions have a model 25 paging encoder, and each primary position consists of a model 4116 rack-mount dispatch console, three model 4115 console expanders and a model 21 instant recall recorder. The auxiliary I/O controls the voting system.

Ground control

E.F. Johnson 99-channel VHF/UHF mobile units are linked to Zetron 230Z remote control devices. These devices are tied to an E&M* channel at the console to give dispatchers access to police departments, the turnpike authority and other entities that might need to communicate with the aircraft. The dispatcher can show the selected frequency as a channel on the console for coordination, cross-patching and other requirements. In effect, the dispatcher can access any ground unit in the coverage area almost instantly through the console and the 99-channel base station.

The transmission system works extremely well, Bothwell said. "We can reach our crews virtually anywhere. They can be in the aircraft conducting preflight checks at the base, and we can give them the information they need. We can do the same thing if they're in the aircraft flying along a ridge in Western Pennsylvania. Either way, they're completely accessible. Because we can communicate with them any time they're airborne, we can give them late-breaking navigation information any time."

*Literally, "ear and mouth," originally a telephone company phrase meaning a simultaneous transmit-and-receive (duplex) circuit.

Flight tracking

A computerized flight tracking system takes Global Positioning System (GPS) coordinates at regular intervals and transmits them as data bursts via a dedicated auxiliary VHF radio to the communications center. There, the coordinates are decoded and placed on an electronic map to show aircraft positions. Although that communication is currently done on a voice system (with the data bursts screened from the operator's headsets), STAT MedEvac will soon have a dedicated frequency just to handle navigation data.

A modified AM aircraft radio operates as a four-channel tone remote base tied to a channel on the console. This system functions as a flight-following device for all medevac units that travel through STAT MedEvac's coverage area. In addition to providing communications to aircraft transporting to hospitals in Greater Pittsburgh, the aircraft radio supports

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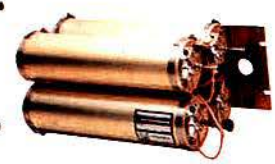
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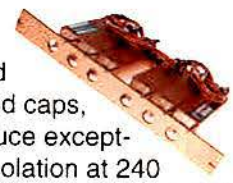




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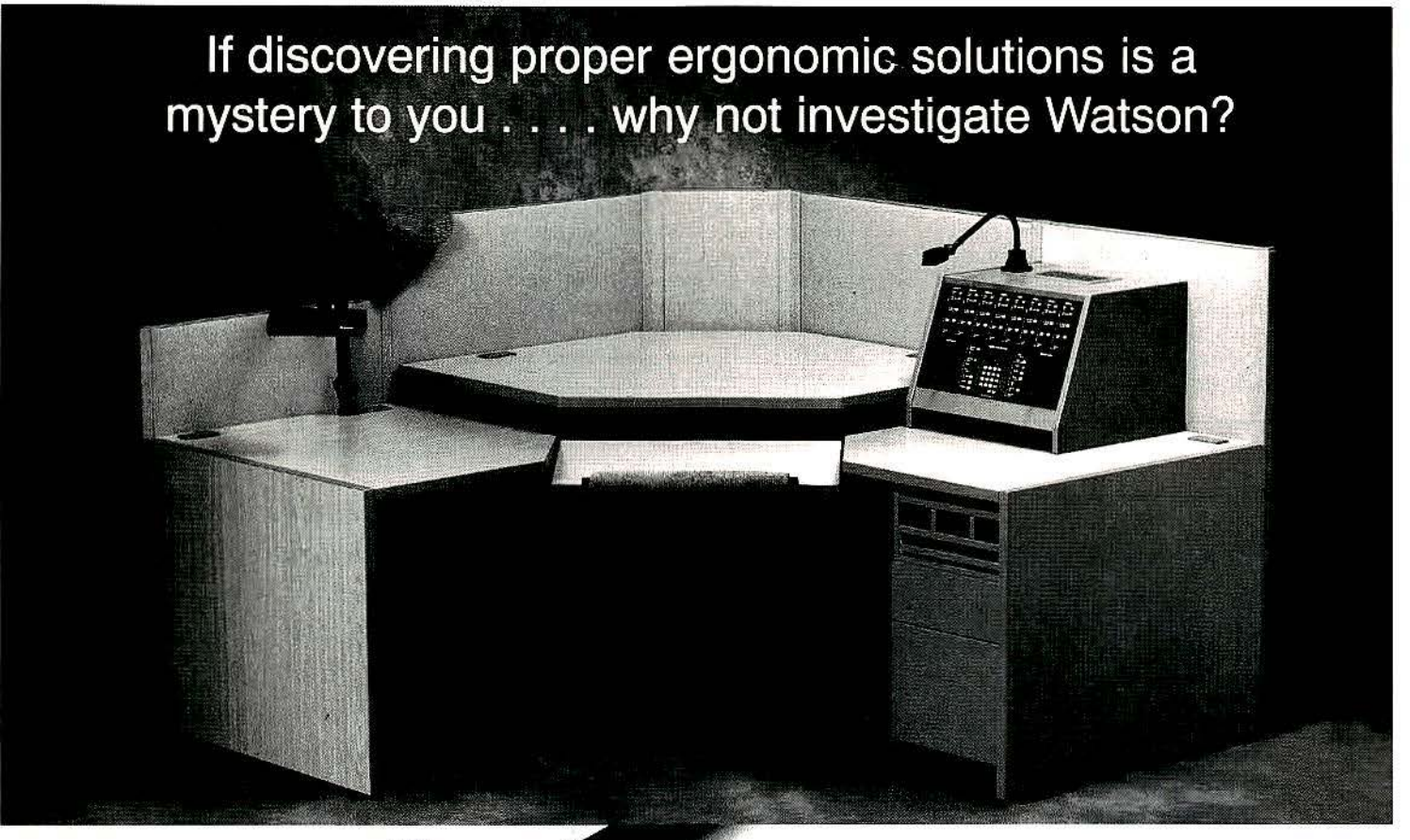
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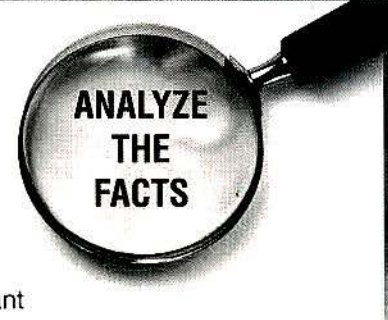
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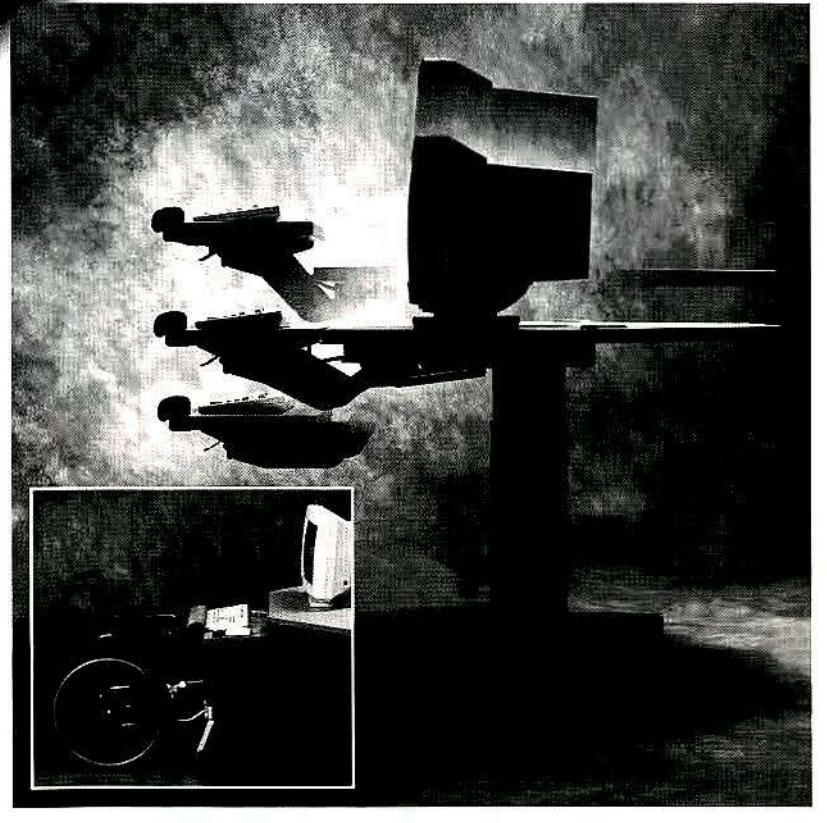
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flight-following for flights simply passing through the area to deliver patients to facilities elsewhere. This base station provides an additional communications path to the aircraft, as well.

For example, a flight originating in Erie, PA, and bound for Baltimore will use Erie's channel until it loses contact, at which time it switches to the STAT MedEvac channel. Upon leaving STAT MedEvac's airspace (or losing radio contact), the flight will switch over to the Harrisburg, PA, channel, perhaps, and eventually the Baltimore channel.

Communication for medevac operations probably is more crucial than for any other type of flight, because the nature of the service places both craft and crew in unusually precarious positions. The ability to link the craft to someone's communications system from takeoff to landing relieves some of the pressure associated with such flights.

Flexible functions

The communication specialists like the system for its flexibility and the integration of a diverse range of functions into a tidy work area, said Bothwell. "For example, the flight crew may be anywhere on the base site when a call comes in. They may be preflighting the aircraft, training, or doing any number of things. When a call for a mission comes in, they need to be reached immediately. [The communications specialists] can call everybody who needs to respond through one preprogrammed button. Groups can also be modified very easily."

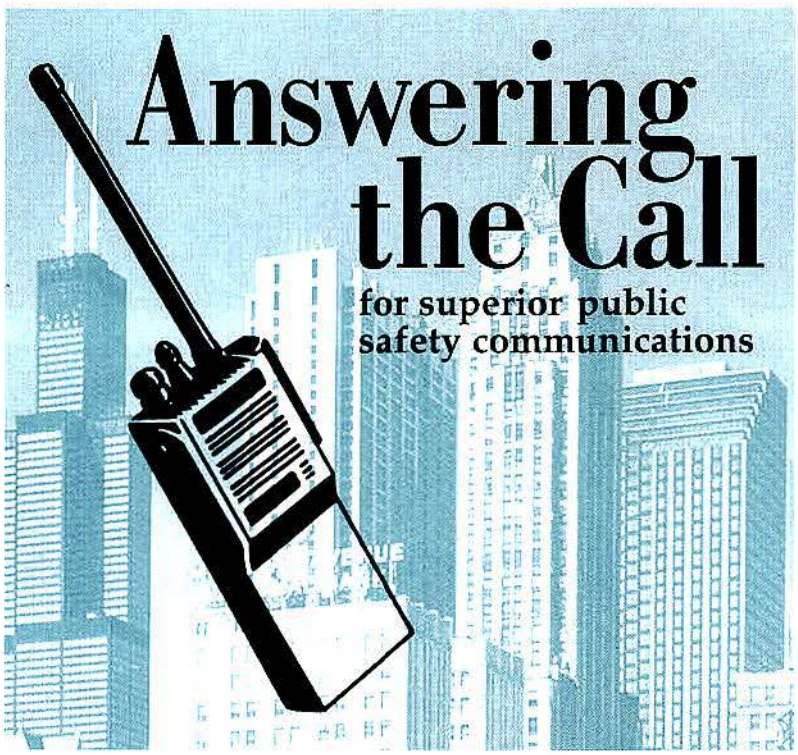
Communications for medevac operations probably is more crucial than for any other type of flight, because the nature of the service places both craft and crew in unusually precarious positions.

Other features they find attractive are the ability to monitor multiple channels simultaneously and the ability to select and unselect channels at the push of a button. The consoles are set up exactly the same, so either communication specialist can handle any task. In addition, programming within the model 25 automatically steers pages through the appropriate transmitter without user intervention.

Innovative Engineering is currently integrating the CAD software into the console via the CAD interface in Zetron's paging encoder. Thanks to the versatility of the interface, a number of operations soon will be automated, making the communication specialists' tasks less tedious. For example, should the communication specialist need to page the crew while an aircraft is en route to a scene, the CAD software will be able to automatically enter the coordinates provided by the navigation software. The model 25, in turn, will be programmed to automatically page the transmitter that provides the best signal for that address.

Usual scenario

Bothwell described the usual scenario:



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"Typically, upon arriving at the scene, the ambulance crew will assess the needs of the injured to determine whether air transport is in order. If they decide it is needed, they simply contact their dispatcher, who in turn, can use either a radio channel or the telephone to request air service. At that point, the dispatcher uses the CAD to determine the best base to activate and to ensure that the craft is available." (If the helicopter is already in service, a prearranged contingency plan is initiated to notify the next base.)

"The dispatcher then sets off an alert tone that activates a siren at the base to alert the pilot and other crew," Bothwell said. "As the pilot is spooling up the engines in preparation to respond, the dispatcher punches in the coordinates to the GPS and provides the ground crew's frequency. And on the way out, the pilot and communications center remain in contact. That way, if information changes, the crew is right on top of it, and if there's a flight emergency, we have it pinpointed instantly."

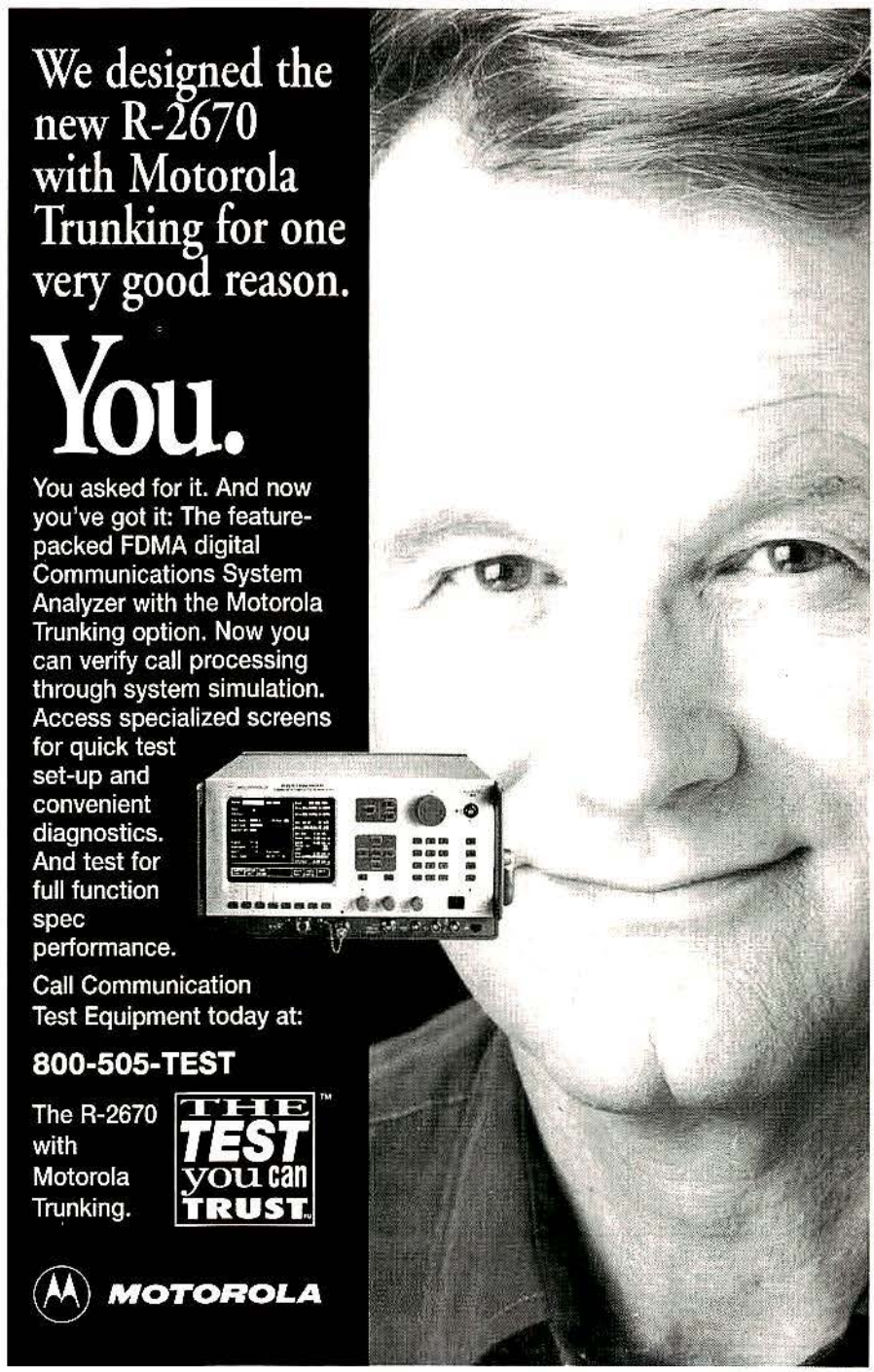
The system works well for ambulance crews, too, he added. "The air crew simply switches over to the ground crew's frequency when they get near the landing zone," Bothwell said. "There's no more guesswork. They know exactly where they're landing and what to expect. The ambulance people can apprise them of any changes that have occurred while they were en route. At that point, they pick up the patient, get airborne, and switch back to a UHF med channel frequency to inform the trauma center of the patient's condition."

Easy system integration

From a reseller's point of view, the system is easy to integrate. From channel configuration to the panel layout, the system is extremely flexible. In this case, the communication specialists wanted a system that could be programmed to operate the way they were accustomed to operating, rather than requiring them to learn new processes. Unfortunately, many vendors say, "We build it one way, and you're going to adapt to it." You get one channel configuration with a specific layout. The customers wanted something that they could set up one way and then, if they decided to try something a little different, the buttons could be moved around for possible improvement.

The flexible programming also makes the system attractive. In addition to being easy to set up and change from the integrator's viewpoint, virtually anything can be done to fit the console to the operator. For example, if the customer wants all the Select keys in one area, the integrator can do it, simply by reprogramming it. If the customer wants to change the keys to a vertical row next week, the console can be reconfigured quickly and easily.

This integrated approach to communications has made life easier for everyone, concluded Bothwell, who logs quite a few hours as a communication specialist himself. "We're very happy with the consoles, both from an administrative and a user's point of view," he said. "And although the transmission coverage isn't perfect yet, it's very acceptable. As time goes on, we're developing fill-in sites closer to the city to provide coverage where the holes exist. The bottom line is that we have a system that is helping to save lives, and that's why we're in business."



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Joint communications project includes four local governments

Multijurisdictional cooperation provides better public safety communications. The Lenoir County, NC, project includes a 9-1-1 center, a computer-aided dispatch system and an 800MHz trunked radio system.

By Charles B. Callahan and Frederick G. Griffin, P.E.

Lenoir County lies about 60 miles east of Raleigh, the capital of North Carolina. Its boundaries embrace the city of Kinston (its county seat) and the towns of Pink Hill and La Grange. The slightly undulated county terrain mixes trees and open fields.

As shown in Figure 1 below, Kinston occupies land slightly east and north of the county center, with La Grange to the west and Pink Hill to the south. The county's economy includes agriculture and light industry. Kinston has residential areas and shopping malls. More than 200 businesses occupy downtown Kinston's "Magic Mile," the county's largest retail and business center.

Important real estate development includes the North Carolina Global TransPark, a communications-driven industrial complex with a cargo airport as the hub of a transportation network. The airport includes a central cargo processing area and industrial sites adjoining the airfield. The initial development phase incorporates about 3,000 acres, including the 1,250 acres of the existing Kinston Regional Jetport, or "Stallings Field," as shown in Figure 1.

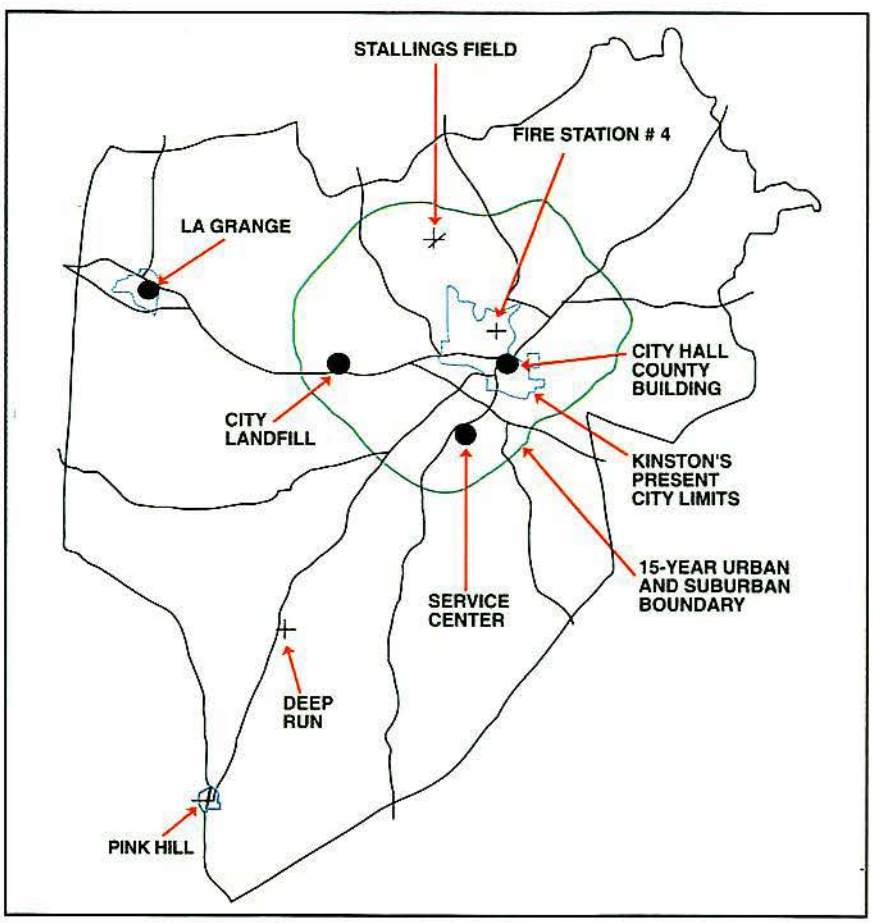


Figure 1. The City of Kinston and Lenoir County public safety communications project includes communications services for the county, the city, the towns of La Grange and Pink Hill, and the airport at Stallings Field.

Splintered communications

In 1991, public safety communications had recognizable problems, including a lack of adequate coverage, aging equipment, restricted airtime availability and a need for mutual aid communications during incidents affecting more than one jurisdiction. Area communications were splintered and organized separately. Responsibility for the county's communications lay with the sheriff's department, which also assisted Pink Hill and La Grange. La Grange's water utility had its own radio system. Kinston had separate systems for public works, the municipal-owned electric utility and public safety (fire and police).

The Kinston city government first investigated these problems, primarily from

Callahan is director of communications, Lenoir County, NC. Tel. 919-559-6150. He belongs to the Associated Public-Safety Communications Officials—International (APCO) and the National Emergency Number Association (NENA).

Griffin is president of Frederick G. Griffin, P.C., a nationwide consulting firm in Lynchburg, VA. Tel. 804-237-2044. He is a member of APCO, NENA, the Radio Club of America and *MRT's* editorial advisory board, and past president of the Association of Federal Communications Consulting Engineers.

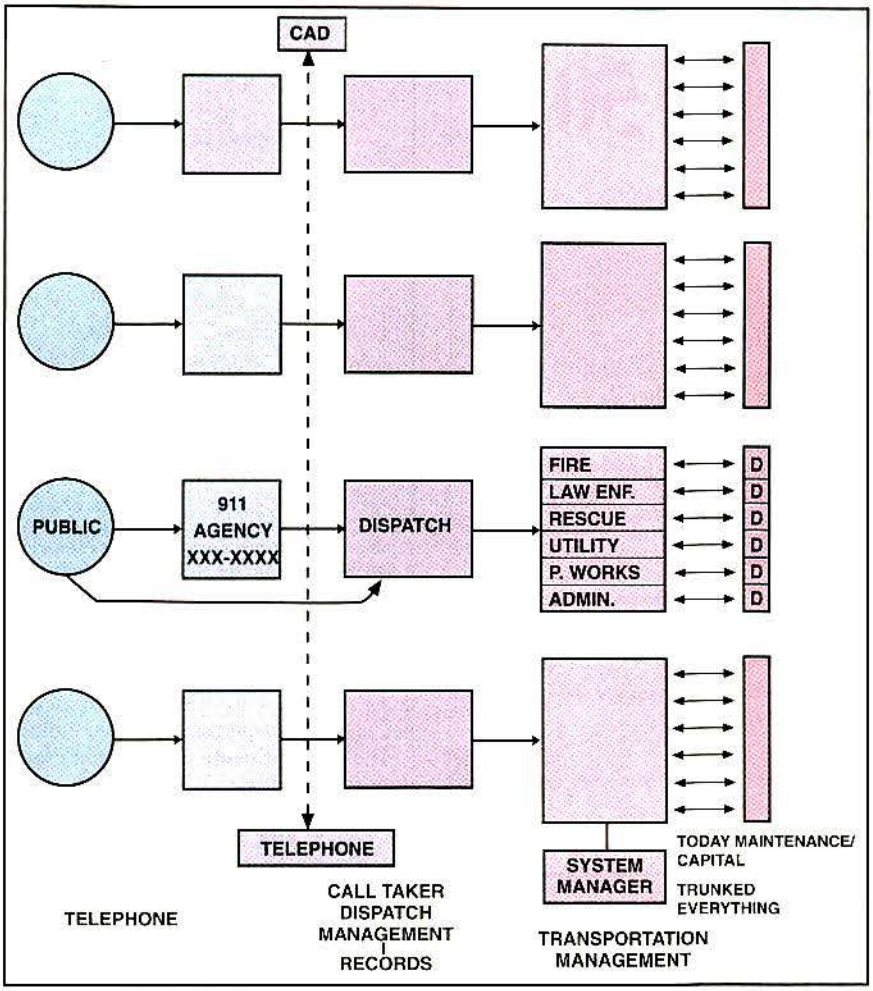


Figure 2. The information flow diagram for consolidated system planning guided the system financing and management structure setup to include a plan for resolving future communications problems.

the city's own point-of-view. As they worked, the planners recognized that fixing yesterday's problems or meeting today's needs was not enough. The key to solving the problems was to plan for future requirements, taking into consideration demographic changes such as population growth, density, distribution and vital statistics. The planners decided that Kinston should not undertake such a large project by itself. The county government and the towns of Pink Hill and La Grange became involved in a cooperative effort with the city.

Information flow

Figure 2 above shows the information flow for consolidated system planning. This diagram guided the system financing and management structure setup to include a plan for resolving future communications problems. Using information furnished by the Kinston zoning office, a 15-year urban and suburban boundary was established as a design requirement. (See Figure 1.)

A three-level coverage design resulted. First, there should be adequate coverage for portable radios along Kinston's Magic Mile. Second, a long-term embedded investment should be made to provide residential coverage to the 15-year growth boundary. Third, adequate coverage for vehicle communications in the rural areas should be provided, and a plan should be included for a future upgrade.

Funds and services

The ever-increasing cost of high-technology communications systems causes leaders to rethink the process of local government. Part of that rethinking involves separating funds and services in a way sometimes referred to as the *public sector triangle.* (See Figure 3 on page 20.) Some local government activities such as public development and public safety services come under the auspices of a "leader and protector." The second sector of the triangle is a "trusteeship" for grants, gifts and entitlements. The third sector includes funds

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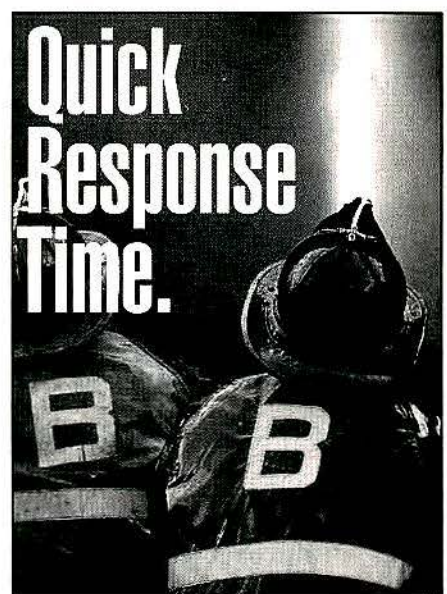


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Figure 3. The *public sector triangle* represents a separation of funds and services that helps leaders to rethink government processes in the face of the cost for high-technology communications systems. The Lenoir County project drew funds from all three sectors.

and partnerships for services such as utilities and joint ventures with other entities.

The Lenoir County and Kinston project uses funding from all three sources. Tax revenues pay for mobile and portable units for police, fire and municipal services. Enterprise activity funding, including the utilities, pays for their equipment. Grant money supports the 9-1-1 center and fixed equipment.

Resource consolidation

To control their communications system cost, local governments often consolidate their resources. This teamwork typically involves dispatching from a unified 9-1-1 center and using 800MHz trunked radios. Trunking allows multiple "talk groups" to share the same pool of radio channels. Talk groups can be defined in separate jurisdictions or within the same jurisdiction. Talk groups are operationally independent in that members of one group can talk to each other without hearing or even being aware of members of any other talk group. Since talk groups are set up in computer software, they can be readily and quickly reconfigured. For example, during mutual aid communications, police and fire departments of separate jurisdictions can be combined temporarily into a single talk group.

Central management

Before proceeding with construction planning and scheduling, the county had to reassign the communications responsibility from elected officials and place it with the county manager. Extensive participation by representatives of all four jurisdictions

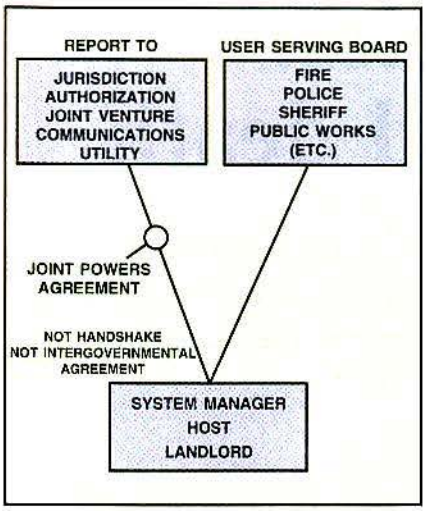


Figure 4. A communications organizational structure similar to that used for Lenoir County reassigns the communications responsibility from elected officials and places it with a host management. With proper financial management and a radio users group, a communications organization can solve its own day-to-day problems without involving the management of participating county, city or town governments.

was required to execute the change. As a result, one of the authors of this article, Charles B. Callahan, was hired as director of communications for Lenoir County. With proper financial management and a participating radio users group, the communications organization can solve its own day-to-day problems without involving the management of the county, city or towns. (See Figure 4 above.)

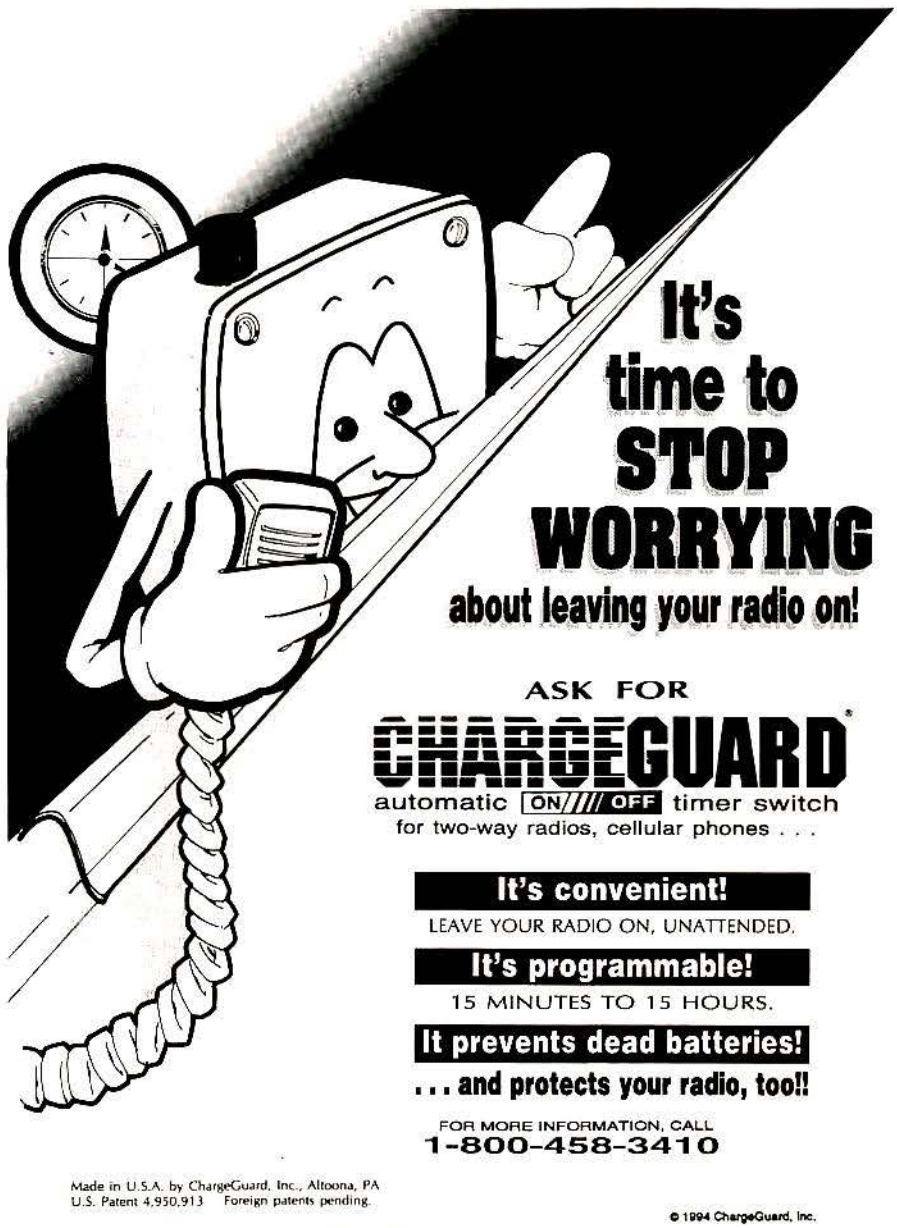
The project evolved to include a consolidated 9-1-1 center, a consolidated computer-aided dispatch (CAD) system and an 800MHz trunked radio system. To provide cost-effective area coverage with limited radio channel availability, the initial trunked radio system design dictated the selection of a single antenna site on an existing tower with two conventional sites to the west and south. The conventional sites are located where they can be phased into a three-site simulcast configuration when necessary and when funding becomes available.

The system was put out for bid in the fall of 1993 and was installed in 1994. The system is up and running with a 9-1-1 center, CAD system and an 800MHz radio system. All information flows through the consolidated center as shown in Figure 2. The system settled in smoothly and satisfactorily, thanks to cost-effective, long-range planning.

Planning and procurement

Records show that vendor-initiated formal protests and lawsuits often result in as many as 90% of government communications system contract awards. Through careful planning and proper procurement procedures, this system incurred no such protests or lawsuits. Since the beginning of this project, the first phase of the Global TransPark has been built. The TransPark provides a small package hub that makes North Carolina products competitive in Europe. The TransPark has come onto the trunked radio system as a tenant user, providing its own dispatch services. Other organizations are considering becoming tenant users. As the area develops and as new economic and service requirements evolve, the system will continue to be a communications infrastructure backbone and eventually will expand to a multisite simulcast system.

This project is a testimony to good planning and multijurisdictional cooperation blended with high technology to provide better service to the public.



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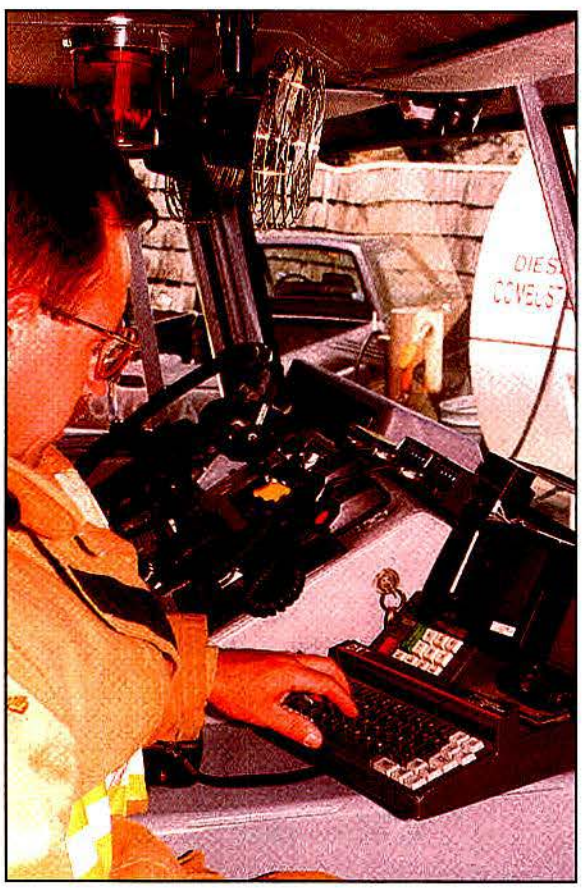
Radio frequencies: A matter of life and death

Database information moves quickly between host computers and public safety workers on a public 900MHz wireless data communications network. Departments in the District of Columbia and Kansas are among the users.

By Tom Langan

Mobile professionals who use wireless data communications to access E-mail, to place orders or to check inventory levels might not think of radio frequencies as a matter of life and death. In the public safety sector, though, many people believe that a "wireless" communications capability sometimes makes the critical difference. Receiving key information without delay increases the safety of mobile workers and the communities they serve. When racing to fight fires or to confront suspects at a crime scene, firefighters and police officers put a premium on information that helps them decide how to proceed.

Historically, the obvious need for efficient, untethered communications has placed public safety agencies among the early adopters of mobile communications. In the past, police and fire departments constructed private communications systems based either entirely on voice or on a combination of voice and data communications. These systems were used for various functions including dispatching, sharing information stored in databases and communicating among mobile units in the field.



Overland Park, KS, firefighter EMT Joe Flake checks a terminal used by the city's fire department to communicate via Ram Mobile Data's 900MHz radio network.

Today, agencies are finding it more efficient to exchange information in written form (data) rather than voice. With an increasing amount of critical information residing on local area networks (LANs) and computer databases, private voice communications or shared voice-and-data systems no longer satisfy the requirements of many agencies. Many police and fire departments are selecting public wireless data communications service and decreasing the role of voice communications in day-to-day operations.

Voice under fire

In Kansas, for example, the Overland Park Fire Department has enhanced a private radio system that featured voice and data communications over a shared radio frequency. "Using a single, shared radio channel for both voice and data communications was extremely inefficient because sending data interfered with using the channel as a voice channel," said Chief Bill Jahnke. "The system would have to wait for a lull in voice communications to transmit data. If the channel were busy, it would try to re-transmit the data as many as five times."

The department had other problems with the system, some merely annoying, others more detrimental. "As data went out, there was a very annoying high-pitched squeal that everybody had to listen to," Jahnke recalls.

Coverage was also an issue. The department serves a 60-square-mile area and answers more than 4,000 calls per year. "We had one repeater and coverage in about 90% of the city. When fighting fires at the outer limits of town, we experienced some problems," Jahnke says.

In Washington, DC, the Metro Police Department faced similar networking challenges. Like the Overland Park Fire Department, the MPD was operating its own private voice network. In 1994, Chief Fred Thomas announced an aggressive plan to counter the rising number of crimes and officer fatalities. As part of

Langan is director of product management at Ram Mobile Data, New York. Ram Mobile Data operates the 900MHz public wireless data communications network described in this article.

Thomas' program, the department decided to overhaul its outdated communications system. The MPD wanted more efficient dispatch, faster access to information on databases, more efficient reporting procedures and the ability to have separate conversations take place concurrently between officers and dispatchers or other mobile units.

"We were using voice communications exclusively, so dispatch and communications between mobile units in emergency situations had to take precedence over everything else," says Thomas. "Officers had to radio in to dispatchers to run checks on vehicle registrations or individuals' police records. It could take as long as five minutes for the busy dispatchers to check the databases and report back to the mobile units. If an officer couldn't wait that long before approaching a suspect, the officer would have to enter potentially life-threatening situations without the benefit of information that could make a big difference in how the officer would act."

After consulting with systems integrators that specialize in the design and deployment of public safety communications systems, both departments opted for public, bi-directional, wireless data communications services.

Selecting a data protocol

The public network that the departments chose uses 900MHz digital, packet-switched technology. Based on the widely used Mobitex protocol, the service is designed and optimized for data. The proliferation of Mobitex-compatible modems, applications and development tools benefits users that lack superfluous time or resources to expend.

With coverage and seamless roaming in more than 92% of the U.S. business population, the network operator plans continued expansion and fortification of its network. The imminent capacity for international roaming, portability and database access via Mobitex networks promises to further dismantle barriers of space and time.

'Free channel'

In expanding the fire department network, Chief Jahnke wanted to ensure firefighters immediate access to data garnered through daily building inspections. The department keeps mission-critical information—profiles on every commercial property in the city—stored in databases. These profiles provide lists and locations of hazardous materials located on the premises, the probable locations of disabled occupants within buildings and the people who should be notified in emergencies. The chief did not want firefighters to have to wait for lulls in voice conversation to retrieve this information.

Voice communications, including dispatch instructions, driving directions and communications among vehicles, still take



Mobile data communications equipment aboard pumper trucks such as this one provides Overland Park, KS, firefighters with immediate, en route access to city databases on the location of hazardous materials or disabled persons at the mission site.



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priority on the department's private radio communications network, but building profiles and other data no longer ride standby on the voice network. Data now travel first-class on the public network.

Before turning to the public network, the department explored several other options. "We considered adding a second channel for data communications," said Chief Jahnke. "Besides the fact that available frequencies are becoming scarce in this area, we found the 900MHz network service to be more efficient, cost-effective and easy to implement."

The department also had considered installing cellular phones that could transmit data but rejected the option as the least efficient of all considered. "With cellular, you still can't transmit data if the line's busy," Jahnke explained. "Besides that, we didn't feel the technology was developed to the point of the wireless data system."

Jahnke said the department is paying about $300 per month for service. "Securing another radio frequency would have been difficult and costly, and we would have had to deploy the resources to maintain it," Jahnke says. "Installing the wireless data network was the equivalent of gaining another channel without going through the FCC process in order to do it. It was like getting a second channel for free. And we don't have coverage problems anymore."

Migrating to wireless data proved to be quick and cost-efficient. The department did not have to replace its existing mobile data terminals (MDTs) from Coded Communications. "We simply added network interface cards and attached wireless data modems from Ericsson," Jahnke says. "We made minimal modifications to the database, did some re-coding on the access program, and that was it."

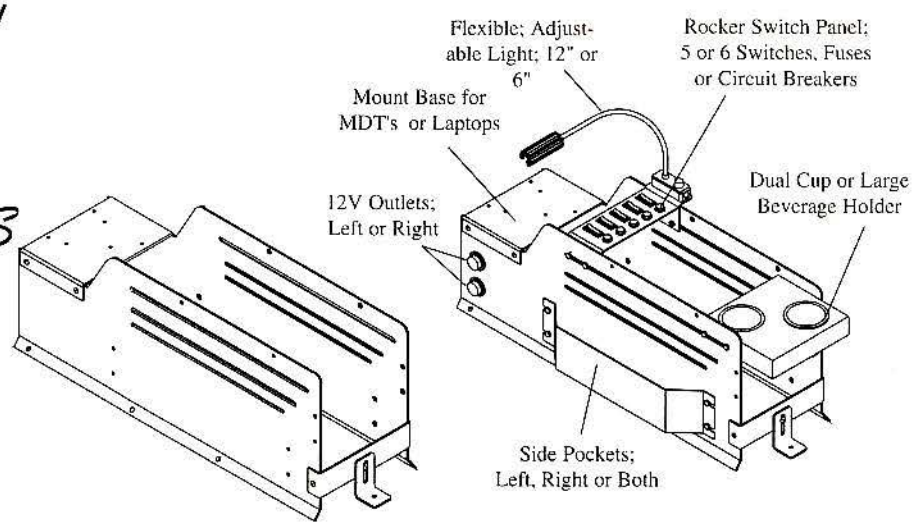
Officer safety and productivity

Because the MPD chose to overhaul rather than to expand its existing private system, its move to data-only service was a more dramatic change than that of the Overland Park department. The MPD invested in laptop computers as well as Ericsson wireless modems, and officers had to learn to use the new equipment. The DC Police Department uses pen-based computers running Windows with MobileLink computer software from Infotech International.

Before implementing wireless data-only communications, the MPD considered an integrated voice-and-data solution based on cellular digital packet data (CDPD) technology. Cellular network operators are currently testing and developing CDPD technology, compatible hardware and applications. Some have joined to establish the CDPD Forum. In the group, operators will tackle the formidable job of negotiating the roaming agreements necessary for seamless coverage. After evaluating the cost, security and reliability CDPD could provide, the MPD rejected the option in favor of the 900MHz public wireless data network. "CDPD would have been more costly, and we don't think we could have gotten the level of service we have now with the 900MHz network," Chief Thomas said.

Almost immediately, MPD users became more productive with the new system. The system features computer-aided dispatch (CAD) capabilities that replace voice communications with data. Dispatchers can send messages to multiple vehicles simultaneously, advising all mobile units of a situation that requires immediate attention. Available units can send messages to the dispatcher and to each other that they are proceeding to a crime

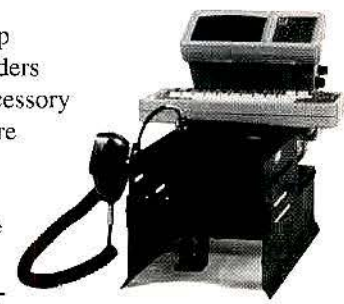
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scene. Critical backup time is reduced.

The new system also relieves dispatchers of the responsibility for running database checks. From the field, mobile users can access stored information directly from their laptops. Bypassing the dispatcher allows officers to initiate and complete registration and license plate checks and to access state and federal information agency databases in seconds rather than minutes.

Last fall, 23 mobile units were equipped with wireless data communications equipment. The department hopes to have the application rolled out to all of its 300 units by the end of this year. The initial users experienced greater productivity immediately.

Besides facilitating dispatch and database access, the solution shaves multiple steps off the administrative process by allowing officers to fill out and send reports from their mobile computers on the spot. The ability to forward reports to multiple parties cuts down on time spent copying and distributing reports between units and divisions.

Wireless also affords greater security than circuit-switched cellular voice. Messages are scrambled and divided into individual packets of data before being sent. With multiple channels available for transmission, it becomes virtually impossible for would-be eavesdroppers to isolate and tap into a certain frequency.

What's next

Advances in development tools and concentrated efforts by industry standards forums continue to make two-way wireless data communications the best choice for "anytime, anywhere" communications among many mobile professionals and work groups.

Soon wireless applications permitting the transmission of graphics will help public safety departments . . . and other professionals be even more productive.

Systems integrators and software developers continue to create and package off-the-shelf wireless data products designed to increase the efficiency of professionals in traditionally mobile environments such as public safety, field service, field sales, courier service and transportation operations. Wireless data communications is also changing the way professionals in other industries work by allowing stock trading, credit card authorization, E-mail transfer and the polling of utility meters.

Soon wireless applications permitting the transmission of graphics will help public safety departments, journalists, real estate brokers and other professionals be even more productive. Moreover, traditional "store-and-forward" capabilities have been improved by development tools from Oracle that let developers build proactive data alert capabilities into applications. Now available for use on Mobitex networks, Oracle's tools allow data to find users before they even know they need it.

As Chief Thomas says, "In some situations, information does officers in the field more good than weapons or equipment."



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Chicago's new 9-1-1 system

By Don Bishop

Five principle elements form the new Chicago 9-1-1 emergency communications system, including more than 200 facilities, a computer-aided dispatch (CAD) system, an internal secure communications network, sophisticated 9-1-1 system, and data and voice radio systems that were integrated by Fluor, Irvine, CA.

▶ *Facilities* — The most visible aspect of the system is the Chicago Emergency Communications Center at 1411 W. Madison St. (See Photo 1 on page 27.) The center includes a briefing room (much like an auditorium), an operations floor (the call-taking and dispatching area; see cover photo) and an emergency situation room with furnishings and telecommunications equipment that can be reconfigured to fit each emergency. Other facilities include a combination alternate response program and backup facility, 109 fire department facilities, 28 police facilities and other city and remote voice and data radio sites.

Redundant water, sewer, electrical and gas sources ensure uninterrupted operation even during power outages. Two separate power leads connect with two separate utility sites. If one service should fail, the other would supply 100% of the demand. Two 1,300KVA gas generators would provide power if a substation or transformer were to fail. Batteries can sustain the electronic equipment for as long as an hour while the generators start.

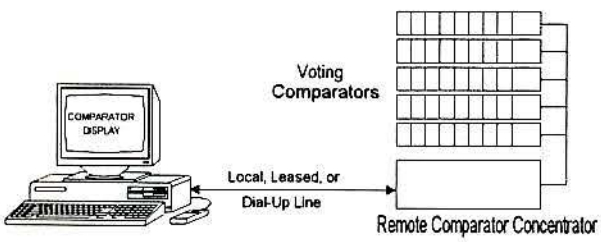
▶ *Sophisticated 9-1-1* — Enormous computer capacity combined with high-bandwidth fiber-optic connections allows callers to be connected with the center in about 1.2 seconds. Once connected, 99% of calls will be answered in less than 10 seconds (two rings or less). Under the old system, about 60% of calls are answered within two rings, and during peak hours, calls could ring as many as seven times.

Much happens during the 1.2 seconds. Automatic number identification (ANI) and automatic location identification (ALI) equipment records the caller's phone number and the phone's location (except for cellular calls). Software linking the 9-1-1 system with a detailed computerized database accesses a map of the caller's neighborhood during the 1.2 seconds. As soon as a call-taker answers, a video display terminal (VDT) displays the map. The map scale and positioning relative to the caller's location can be adjusted at will. Environmental Systems Design, Chicago, built the map that goes into the display system.

The database includes footprints of virtually every building in Chicago, as well as many still and moving video images of buildings and information about their contents. Information from surveys mailed to residents helps to identify people and their special requirements, if any, where the call originates.

▶ *CAD system* — An Altaris graphical user interface CAD system from PRC, McLean, VA, includes six DEC model 2100-4/275 Alpha servers each with dual AXP 64-bit central processing units. These

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Photo 1 (left). The new Chicago 9-1-1 system's keystone is the five-story, 161,000-square-foot Chicago Emergency Communications Center, which houses a briefing room, an operations floor with 108 call-taking and dispatching consoles, and an emergency situation room, along with offices and working areas for administrators and technical staff.

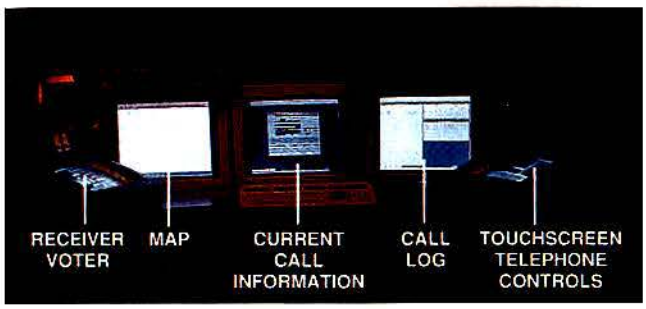


Photo 2. Consoles have five VDTs to obtain information and process calls. Console lighting and airflow controls, along with desk height and angle adjustments, allow call-takers to modify their working conditions. The furniture is made by Evans Consoles, Calgary, Alberta, Canada.

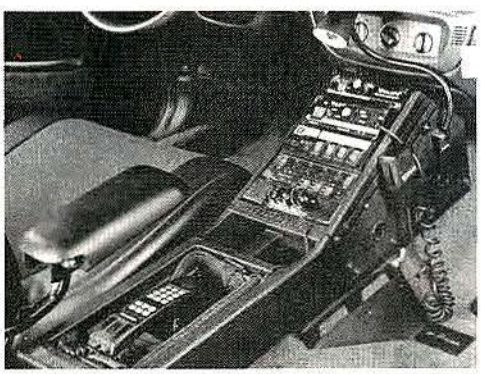
servers operate in pairs arranged in asymmetric clusters. The clusters serve the police and fire CAD, and communications control.

Each of the 108 operations floor workstations has a DEC Alpha model 3000-300 X personal computer with 64-bit CPU (175MHz processing speed), 32Mb memory, 426Mb disk, 10Base-T ethernet and 600Mb compact disk read-only memory (CD-ROM). Dispatch and supervisor workstations have three 21-inch monitors. Call-taker workstations have two 21-inch monitors.

The CAD system is coupled with an interactive map display system, a digital dispatch system and several interfaces to external computer systems. The CAD system stores a number of information files that are searched automatically upon incident entry for hazardous material data and premise history and that automatically verify address information.

Call-takers use five VDTs to obtain information and process calls. The terminals display receiver voter activity, the map, caller data retrieved from computer files and entered by the call-taker, other calls in

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progress and telephone touchscreen controls. (See Photo 2 on page 27.)

An automatic vehicle location (AVL) system gives dispatchers accurate locations of all fire and emergency medical vehicles, reducing response time and ensuring selection of the closest unit.

▶ *Internal network* — More than 175 miles of new fiber construction, electronic equipment at more than 43 node sites and related electronics at more than 200 facilities form the system's internal secure communications network (ISCN). The secured communications network links police, fire and and other city facilities, allowing instant transfer of case reports, photos, arrest records and other vital or confidential information.

▶ *Radio communications network* — A network of data transmitters installed throughout the city supplements the city's existing voice radio networks. Most voice communication is carried on UHF and VHF analog FM channels already used by the police and fire departments. In addition to the UHF and VHF dispatch system, the police department uses an 800MHz trunked system with encrypted voice to communicate with its narcotics and special operations units.

The police department received licenses a few months ago for 800MHz frequencies allocated under the National Public Safety Planning Advisory Committee (NPSPAC) Chicago regional frequency plan—just in time to devote 26 800MHz channels for data communications. Extensive use of data terminals in vehicles and portable data terminals in the field is expected to reduce voice traffic dramatically, preserving radio airtime for emergency use. The data network can carry as many as 150,000 messages per hour.



Photo 3. The Motorola Forté pen-based terminal is among several models being field-tested.

The city is conducting a field ("beta") test of portable data terminals with integral RF modems. Products under evaluation include models provided by Motorola, Telxon, Badger, Itronix and M3I. The Motorola Forté pen-based terminal shown in Photo 3 above eliminates keyboard use until the police officer wants to use the keyboard. On dispatching, many of the display fields are filled in. The unit can be equipped with a bar code reader. The terminal makes it easy to complete reports in the field. The Motorola PDT 220 portable data terminal shown in Photo 4 below improves the convenience of data communications on foot.

The console radio electronics and voice radio switch were supplied by CML Technologies, Hull, Quebec, Canada. The voice radio switch uses digital switching to control 60 operator positions and 60 voice radio channels. The voice radio switch connects with the remote radio sites via the ISCN fiber network.



Photo 4. Motorola PDT 220 portable data terminals extend data communications to officers on foot.

In an unusually practical configuration, the area of an entire floor below the operations floor serves as as a technical room. The room houses racks of equipment controlled by the consoles above. This arrangement leaves plenty of space for technicians to work without entering the operations floor. It eliminates the sometimes-squeaky computer floors used in some communications centers. Next-generation equipment can be installed alongside the present equipment when the time comes, making it unnecessary to relocate to temporary facilities during future construction.

Emulation testing began during the week of June 15, so full operation of the new Chicago 9-1-1 system cannot be far behind.



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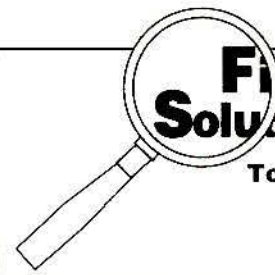
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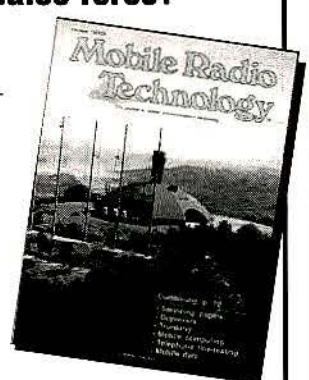
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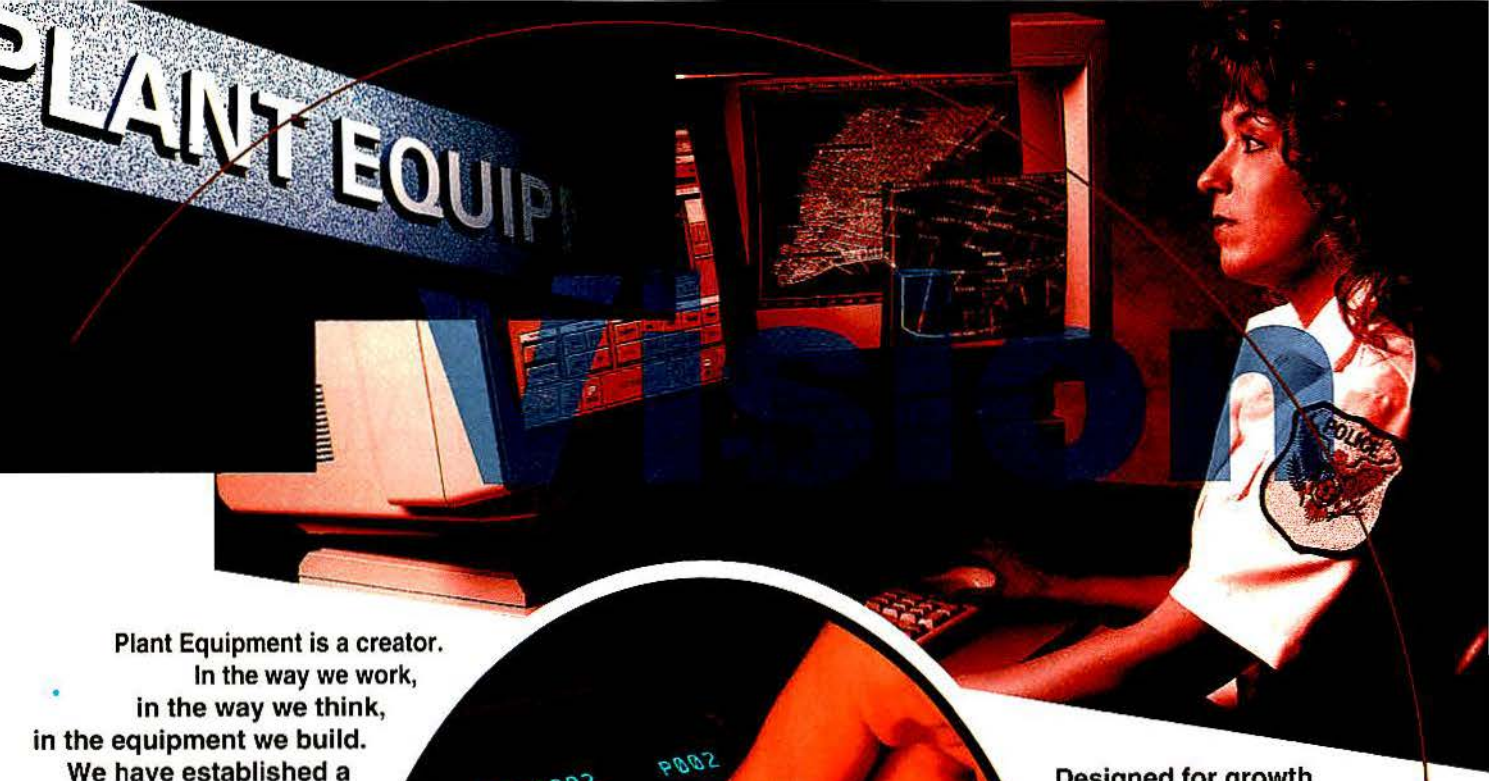
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SAME PHYSICS.
SIMILAR PARTS.
NEARLY IDENTICAL FEATURES.
RADICALLY DIFFERENT
UPBRINGING.



THERE'S MORE TO A RADIO COMMUNICATIONS SYSTEM THAN A WELL KNOWN NAME. HERE'S WHY THE MULTI-NET II SYSTEM STANDS OUT FROM THE COMPETITION: ▲ Multi-Net II combines innovation and over 70 years of E.F. Johnson radio experience to satisfy the most demanding system managers. Multi-Net II offers the same capabilities as other systems—like unique IDs, networking with auto-registration, and simulcasting—plus unique technology such as dynamic channel allocation, and a clear path to our Jade™ and APCO-25 digital environments. Multi-Net II systems are built with a different attitude as well, by a team that believes in working with customers, not dictating to them. If you're looking for a new radio system, look beyond the name to the technology and people that stand behind it. Call us at 1-800-328-3911 ext. 6380. ▲ **INTELLIGENT CHOICES FOR A WIRELESS WORLD.™**

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